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*Indian Standard*  
**OPTICAL FIBRES**  
**PART 1 MEASUREMENT METHODS AND TEST PROCEDURES**  
**Section 54 Gamma Irradiation**

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## NATIONAL FOREWORD

This Indian Standard (Part 1/Sec 54) which is identical with IEC 60793-1-54 : 2003 'Optical fibres — Part 1-54: Measurement methods and test procedures — Gamma irradiation' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Fibre Optics, Fibres, Cables and Devices Sectional Committee and approval of the Electronics and Information Technology Division Council.

The text of IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

- a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
- b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

| <i>International Standard</i>                                                                                  | <i>Corresponding Indian Standard</i>                                                                                   | <i>Degree of Equivalence</i> |
|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|------------------------------|
| IEC 60793-1-40 : 2001 Optical fibres — Part 1-40: Measurement methods and test procedures — Attenuation        | IS/IEC 60793-1-40 : 2001 Optical fibres: Part 1 Measurement methods and test procedures, Section 40 Attenuation        | Identical                    |
| IEC 60793-1-44 : 2011 Optical fibres — Part 1-44: Measurement methods and test procedures — Cut-off wavelength | IS/IEC 60793-1-44 : 2011 Optical fibres: Part 1 Measurement methods and test procedures, Section 44 Cut-off wavelength | do                           |

Only the English language text has been retained while adopting it in this Indian Standard and as such the page numbers given here are not the same as in the IEC Publication.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

# *Indian Standard*

## OPTICAL FIBRES

### PART 1 MEASUREMENT METHODS AND TEST PROCEDURES

#### Section 54 Gamma Irradiation

## 1 Scope

This part of IEC 60793 outlines a method for measuring the steady state response of optical fibres and optical cables exposed to gamma radiation. It can be employed to determine the level of radiation-induced attenuation produced in single-mode or multimode optical fibres, in either cabled or uncabled form, due to exposure to gamma radiation.

The attenuation of cabled and uncabled optical fibres generally increases when exposed to gamma radiation. This is primarily due to the trapping of radiolytic electrons and holes at defect sites in the glass (i.e. the formation of "colour centers"). This test procedure focuses on two regimes of interest: the low dose rate regime suitable for estimating the effect of environmental background radiation, and the high dose rate regime suitable for estimating the effect of adverse nuclear environments. The testing of the effects of environmental background radiation is achieved with an attenuation measurement approach similar to method IEC 60793-1-40A, cut-back. The effects of adverse nuclear environments are tested by monitoring the power before, during and after exposure of the test sample to gamma radiation. The depopulation of color centers by light (photobleaching) or by heat causes recovery (lessening of radiation induced attenuation). Recovery may occur over a wide range of time which depends on the irradiation time. This complicates the characterization of radiation induced attenuation since the attenuation depends on many variables including the temperature of the test environment, the configuration of the sample, the total dose and the dose rate applied to the sample and the light level used to measure it.

This test is not a material test for the non-optical material components of a fibre optic cable. If degradation of cable materials exposed to irradiation is to be studied, other test methods will be required.

NOTE Background information on this subject is given in IEC/TR 62283<sup>1</sup>.

Attention is drawn to the fact that strict regulations and suitable protective facilities are adopted in the laboratory for this test. Carefully selected trained personnel are used to perform this test. It can be extremely hazardous to test personnel if it is improperly performed or without qualified conditions.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60793-1-40:2001, *Optical Fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

IEC 60793-1-44:2001, *Optical fibres – Part 1-44: Measurement methods and test procedures – Cut-off wavelength*

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<sup>1</sup> IEC 62283, *Nuclear radiation – Fibre optic guidance*.

### **3 Apparatus**

#### **3.1 Radiation source**

##### **3.1.1 Testing of environmental background radiation**

A  $^{60}\text{Co}$  or equivalent ionising source shall be used to deliver gamma radiation. This environment is characterised by relative low dose and dose rate.

##### **3.1.2 Testing of adverse nuclear environments**

A  $^{60}\text{Co}$  or equivalent ionizing source(s) shall be used to deliver gamma radiation. This environment is characterised by higher total dose and dose rate.

#### **3.2 Light source**

A light source such as a tungsten-halogen lamp or set of lasers or LEDs shall be used to produce radiant energy at wavelengths of 850 nm, 1300 nm and 1550 nm or at wavelengths as specified in the detail specification. The light source shall be stable in intensity over a time period sufficient to perform the measurement. The power coupled from the source into the test sample shall be  $<30$  dBm (1,0  $\mu\text{W}$ ) or as specified in the detail specification. The light source shall be modulated with a pulsed signal at a 50 % duty cycle.

NOTE If a source that couples more than 1,0  $\mu\text{W}$  is used, photobleaching may occur.

#### **3.3 Optical filters/monochromators**

Unless otherwise specified, wavelengths of  $(850 \pm 20)$  nm,  $(1300 \pm 20)$  nm, and  $(1550 \pm 20)$  nm shall be obtained by filtering the light source with a set of optical filters or a monochromator. The 3 dB optical bandwidth of the filters shall be less than or equal to 25 nm.

#### **3.4 Cladding mode stripper**

When necessary, a device that extracts cladding modes shall be employed at the input end and output end of the test sample. If the fibre coating materials are designed to strip cladding modes, a cladding mode stripper is not required.

#### **3.5 Fibre support and positioning apparatus**

A means of stable support for the input end of the test sample such as a vacuum chuck, shall be arranged. This support shall be mounted on a positioning device so that the end of the test sample can be repeatedly positioned in the input beam.

#### **3.6 Optical splitter**

An optical splitter shall divert a small portion of the input light to a reference detector. The reference path shall be used to monitor system fluctuations for the duration of the test.

### **3.7 Input launch simulator**

#### **3.7.1 Category A1 fibres (graded index multimode fibre)**

An equilibrium mode simulator shall be used to attenuate higher order propagation modes and to establish a steady-state mode condition near the input end of the fibre. Refer to method IEC 60793-1-40A for instructions on how to establish proper launch conditions for Category A1 graded index multimode fibres.

#### **3.7.2 Category B fibres (single-mode fibre)**

An optical lens system or fibre pigtail may be employed to excite the test fibre. The power coupled into the test sample shall be stable for the duration of the test. If an optical lens system is used, a method of making the positioning of the fibre less sensitive is to overfill the fibre end spatially and angularly. If a pigtail is used, it may be necessary to use index matching material to eliminate interference effects. A high order mode filter shall be employed to remove high order propagating modes in the wavelength range greater than or equal to the cut-off wavelength of the test fibre. The test condition specified in method C of IEC 60793-1-44 satisfies this requirement.

#### **3.7.3 Categories A2.1 and A2.2 (quasi-step and step index fibres)**

Launch conditions shall be created as specified in the detail specification.

### **3.8 Detector – Signal detection electronics**

An optical detector which is linear and stable over the range of intensities that are encountered shall be used. A typical system might include a photovoltaic mode photodiode amplified by a current input preamplifier, with synchronous detection by a lock-up amplifier.

### **3.9 Optical power meter**

A suitable optical power meter shall be used to determine that the power coupled from the optical source into the test sample is less than or equal to 1,0  $\mu$ W or the level specified in the detail specification.

### **3.10 Radiation dosimeter**

Thermoluminescent LiF or CaF crystal detectors (TLDs) or an ion chamber detector shall be used to measure the total radiation dose received by the specimen fibre.

### **3.11 Temperature-controlled container**

Unless otherwise specified, the temperature-controlled container shall have the capability of maintaining the specified temperatures to within  $\pm 2$  °C.

### **3.12 Test reel**

The test reel shall not act as a shield or sink for the radiation used in this test. Reels of wood, plastic or similar non-conducting materials would, in principle, act as transparent to the radiation. The additional absorption shall be taken into account for exact measurements.

## **4 Sampling and specimens**

### **4.1 Specimens**

#### **4.1.1 Fibre specimen**

The test specimen shall be a representative sample of the fibre specified in the detail specification.

#### **4.1.2 Cable specimen**

The test specimen shall be a representative sample of the cable described in the detail specification and shall contain at least one of the specified fibres.

### **4.2 Specimen for environmental background radiation test**

Unless otherwise specified in the detail specification, the length of the test sample shall be  $(3\,000 \pm 30)$  m. (Where reactor constraints dictate smaller lengths, the length of the test sample may be  $(1\,100 \pm 20)$  m.) A minimum length at the ends of the test sample (typically 5 m) shall reside outside of the test chamber and be used to connect the optical source to the detector. The irradiated length of the test sample shall be reported.

### **4.3 Specimen for testing adverse nuclear environments**

Unless otherwise specified in the detail specification, the length of the test sample shall be  $(250 \pm 2,5)$  m. (When test conditions require a high total dose and dose rate, a shorter test sample length may be necessary). A minimum length at the ends of the test sample (typically 5m) shall remain outside of the test chamber and be used to connect the optical source to the detector. The irradiated length of the test sample shall be reported.

### **4.4 Test reel**

The test sample shall be spooled onto a reel with a drum diameter that is specified in the detail specification. Allowance shall be made for the unspooling of a measured length of the test sample from each end of the reel to allow for attachment to the optical measurement equipment. An alternative deployment method allows the fibre to be loosely wound in a coil of specified diameter.

### **4.5 Ambient light shielding**

The test sample shall be shielded from ambient light to prevent external photobleaching.

## **5 Procedure**

The radiation tests differ in exposure dose, dose rate, exposure time and temperature. The tests are environmental background radiation test and adverse nuclear radiation test.

### **5.1 Calibration of radiation source**

Calibration of the radiation source for dose uniformity and level shall be made prior to the test sample being set up in the chamber. Four TLDs shall be placed in the area of exposure and the center of the TLDs shall be placed where the axis of the test reel will be placed. (Four TLDs are used to get a representative average value.) A dose equal to or greater than the actual test dose shall be used to calibrate the system. To maintain the highest possible accuracy in measuring the test dose, the TLDs shall not be used more than once.

## 5.2 Preparation and conditioning

The test sample shall be preconditioned in the temperature chamber at  $(25 \pm 5) ^\circ\text{C}$  for 1 h prior to testing, or at the test temperature for a preconditioned time as specified in the detail specification.

The input end of the short test length shall be placed in the positioning device and aligned in the test set to obtain maximum optical power as measured with a calibrated power meter.

The power at the input end of the test sample shall be measured with a calibrated power meter. If necessary, the source power level shall be adjusted so that the power at the input end of the fibre is less than  $1,0 \mu\text{W}$  or as specified in the detail specification.

NOTE If a source that couples more than  $1,0 \mu\text{W}$  is used, photobleaching may occur.

With the radiation source off, the input end of the test sample shall be positioned to obtain maximum optical power at the detector. Once set, the input launch conditions shall not be changed during the gamma irradiation portion of the test.

A chart recorder or suitable continuous measurement device shall be connected to the detection system so that a continuous power measurement can be made. The measurement equipment shall be set up such that the detection signal does not exceed the limits of the equipment.

A  $^{60}\text{Co}$  or equivalent ionizing source(s) shall be used to deliver gamma radiation at a desired dose rate.

Dose rate levels are only approximate levels since the radiation source characteristics change. A variation in dose rate as high as  $\pm 50\%$  can be expected between sources. The time required to turn the radiation source on or off shall be  $< 10\%$  of the total exposure time.

It is important that the temperature is kept constant during the tests. If the test should be performed at different temperatures, then the attenuation prior to irradiation has to be measured for different temperatures for each specified wavelength.

## 5.3 Attenuation measurement for environmental background radiation

An attenuation measurement of the test sample shall be performed, at the specified test wavelengths, in accordance with method A of IEC 60793-1-40, cut-back. The attenuation  $A_1$  of the fibre prior to exposure to the gamma radiation source shall be recorded. The environmental temperature shall be the same as during the up-coming irradiation tests when the initial attenuation measurement is performed.

Environmental background radiation effects, due to exposure to gamma radiation, shall be determined by subjecting the test sample to a nominal dose rate of  $0,02 \text{ Gy/h}$ . The test sample shall be exposed to a total dose of  $0,1 \text{ Gy}$ . Different dose rates and total dose values may be called for in the detail specification in order to simulate particular specific conditions.

Upon completion, and within 2 h of the irradiation process, an attenuation measurement of the test sample shall be performed in accordance with method A of IEC 60793-1-40, cut-back. The attenuation  $A_2$  of the test sample after exposure to the gamma radiation source shall be recorded.

#### 5.4 Attenuation measurement for adverse nuclear environment

The output power from the sample prior exposure to the gamma radiation source shall be recorded.

Adverse nuclear radiation effects, due to exposure to gamma radiation, shall be determined by subjecting the test sample to a nominal dose rate of 1000 Gy/h. The test sample shall be exposed to a total dose of 1000 Gy. Different dose rates and total dose values may be called for in the detail specification in order to simulate particular specific conditions.

The output power from the sample shall be recorded for the duration of the gamma irradiation cycle. With help of the initial attenuation measurements, prior to irradiation, one can determine the radiation induced loss in the fibre.

The power shall also be recorded for at least 15 min after completion of the irradiation process or as specified in the detail specification. The power level of the reference detector shall also be recorded during the recovery time after completion of the irradiation process.

### 6 Calculations

#### 6.1 The change in optical attenuation $\Delta A$ (environmental background radiation test)

$$\Delta A = A_2 - A_1 \text{ dB}$$

where

$A_1$  is the attenuation of the test sample prior to exposure to gamma radiation;

$A_2$  is the attenuation of the test sample after exposure to gamma radiation.

#### 6.2 The change in optical transmittance, $A$ (adverse nuclear environmental radiation test)

The change in optical transmittance  $A$  shall be calculated for each wavelength by using the following formula (testing of adverse nuclear environment):

$$A_0 = -10 \log (P_0/P_B) \quad \text{dB}$$

$$A_{15} = -10 \log (P_{15}/P_B) \quad \text{dB}$$

where

$P_0$  is the power output of the test sample within 1 s after irradiation is discontinued, unless otherwise specified;

$P_{15}$  is the power output of the test sample 15 min after irradiation is discontinued, unless otherwise specified;

$P_B$  is the power output of the test sample before irradiation begins;

$A_0$  is the change in optical transmittance of the test sample immediately after irradiation;

$A_{15}$  is the change in optical transmittance of the test sample 15 min after irradiation.

### 6.3 Normalisation of the results

The results of the reference measurements should be used to normalize the test results if significant system instability is noted.

$$A_{\text{REF}} = -10 \log (P_{\text{E}'} / P_{\text{B}'}) \quad \text{dB}$$

where

$P_{\text{E}'}$  is the power measured by the reference detector at the end of the measurement;

$P_{\text{B}'}$  is the power measured by the reference detector before irradiation begins.

Normalized test results that account for system instability are calculated with the following formula:

$$\begin{aligned} A_{0\text{NOR}} &= A_0 - A_{\text{REF}} \\ A_{15\text{NOR}} &= A_{15} - A_{\text{REF}} \end{aligned}$$

## 7 Results

### 7.1 Information to be provided with each measurement

Report the following information with each measurement:

- date and title of test;
- length of test sample exposed to radiation;
- test wavelengths;
- test temperatures;
- material-, dimensions- and design of the test reel;
- test dose and dose rate;
- change in attenuation  $\Delta A$  (environmental background radiation test);
- change in optical transmittances  $A_0$  and  $A_{15}$  (adverse nuclear environment);
- characteristics of test sample such as fibre type, cable type, dimensions and composition;
- chart recording of test events.

### 7.2 Information available upon request

The following information shall be available upon request:

- description of radiation source;
- description of dosimeters used;
- type of optical source, model number and manufacturer;
- description of optical filters or monochromator;
- description of cladding mode stripper;
- description of input launch simulator and launch conditions used;
- type of optical splitter used;
- description of detection and recording apparatus;
- description of the characteristics of temperature chamber;
- date of latest calibration of test equipment;
- name or identification number of operator.

## **8 Specification information**

The detail specification shall specify the following information:

- type of test sample to be tested;
  - test reel diameter;
  - test temperature(s);
  - failure or acceptance criteria;
  - number of samples;
  - test wavelengths;
  - total dose and dose rate;
  - other test conditions.
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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards: Monthly Additions'.

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#### Amendments Issued Since Publication

| Amendment No. | Date of Issue | Text Affected |
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